Focused beam

Cross-section of intensity

particle
10

$$F_{\nabla} = 2\pi \cdot r^3 \frac{\sqrt{\varepsilon_B}}{c} \left(\frac{\varepsilon - \varepsilon_B}{\varepsilon + 2\varepsilon_B} \right) (\nabla \cdot I)$$

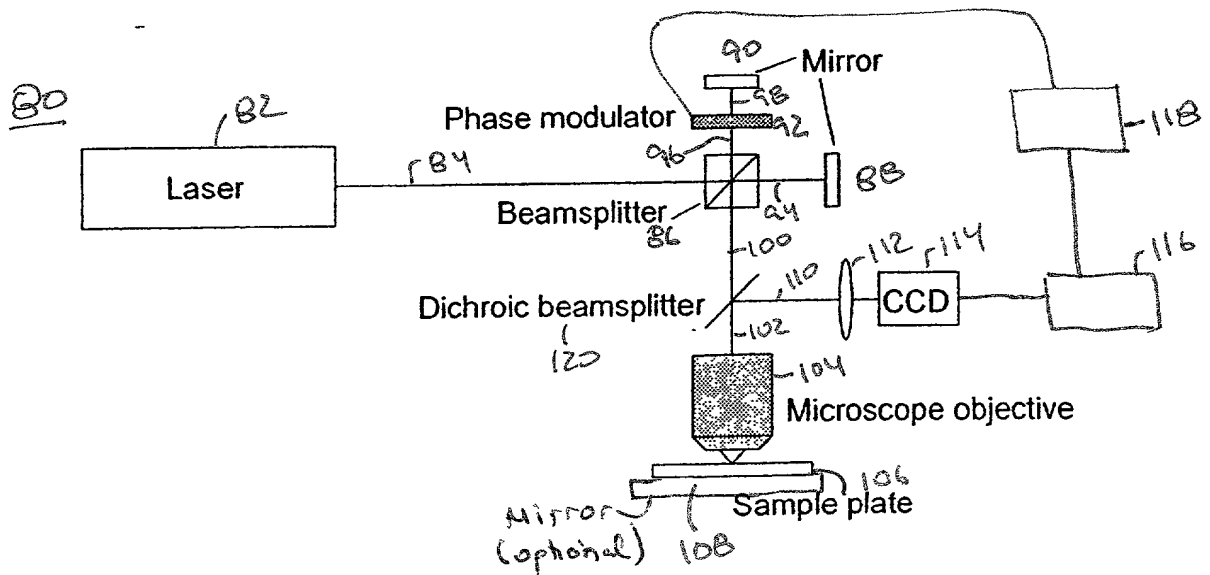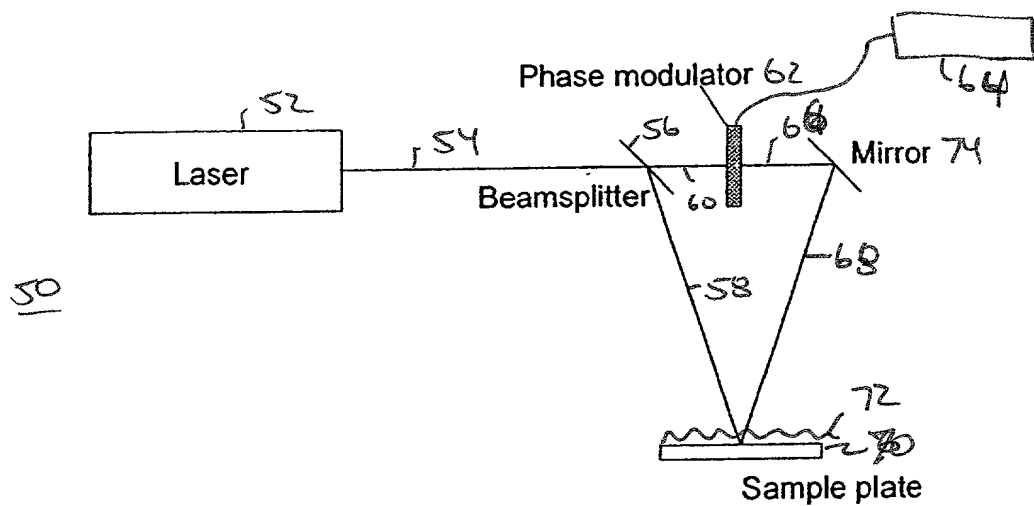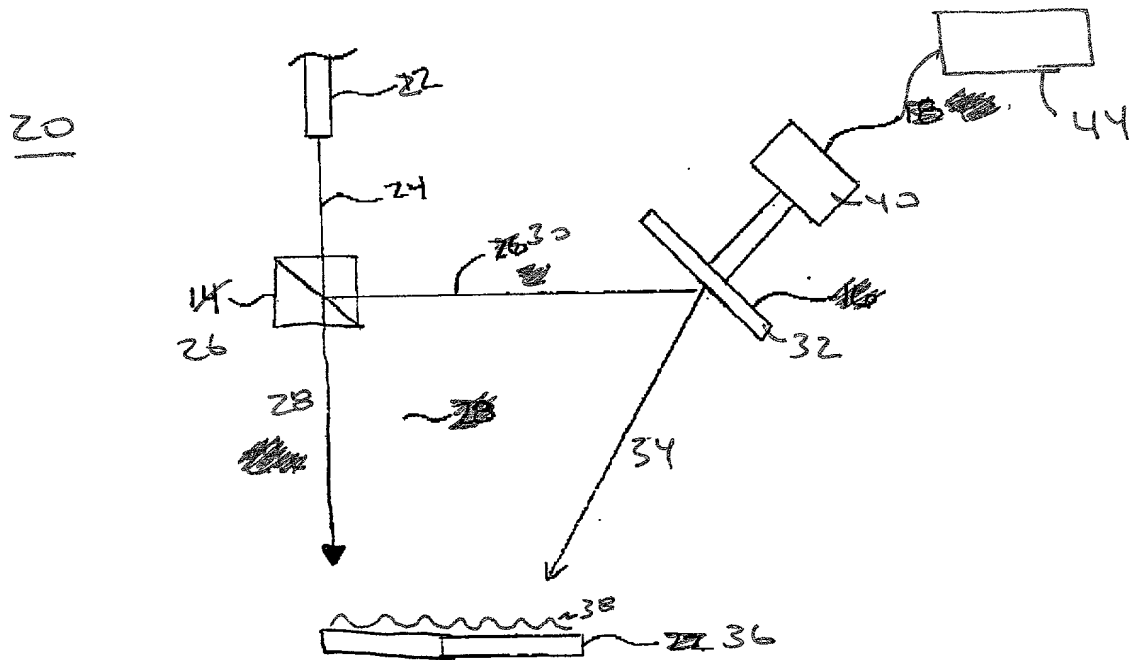F_{∇} = optical force on particle towards higher intensity

r = radius of particle

ε_B = dielectric constant of background medium

ε = dielectric constant of particle

I = light intensity (W / cm^2)

∇ = spatial derivative

Fig. 1

Fig. 2

20

22

24

14
26

28

26 30

32

34

38
36

40

44

Fig. 3

50

52

Laser

54

56

Phase modulator 62

64

Beamsplitter

60

66

Mirror 74

58

68

72

70

Sample plate

Fig. 4

80

82

Laser

84

90 Mirror

98

Phase modulator

92

96

86

Beamsplitter

94

88

118

100

110

112 114

CCD

116

Dichroic beamsplitter

120

102

104

Microscope objective

Mirror
(optional) 108

106

Sample plate

Microscope objective

Levitated particle

Microscope slide

Microscope objective

Fig. 4A

Laser 122

Spatial filter 126

128

130

Beamsplitter

Mirror 132

140

142

144

148

Phase modulator

Mirror

146

172

From Imaging System

150

Fiber light 168

Dichroic mirror 170

152

Sample plate 154

156

Microscope objectives

Mirror 158

IR filter 160

Lens 162

CCD

164

166

To Control System

120

Fig. 5

Fiber light

Dichroic mirror 190

Microscope objectives

192

194

196

Sample plate

Lens 202
202

CCD

200

IR filter

198
Mirror

206
To control system

Spatial filter

186
188

184

182

180
Laser

From imaging system
208

Fig. 6

Fig. 7

Polygonal Mirror

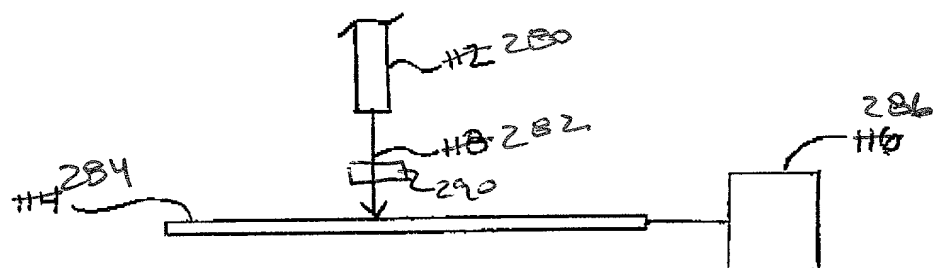Beam Input 262

272

268

270

276

Lens 274

Galvanometer or
Resonant scanner 264

Scan Area 260
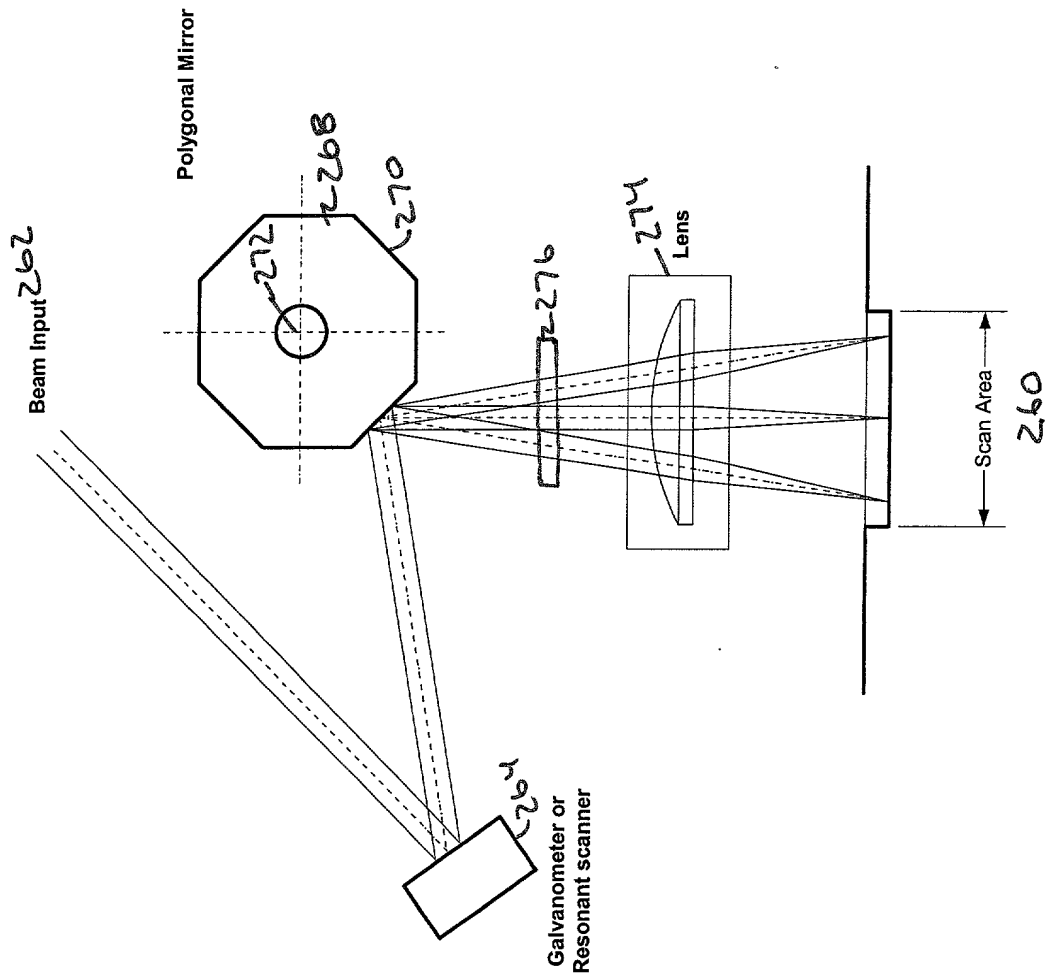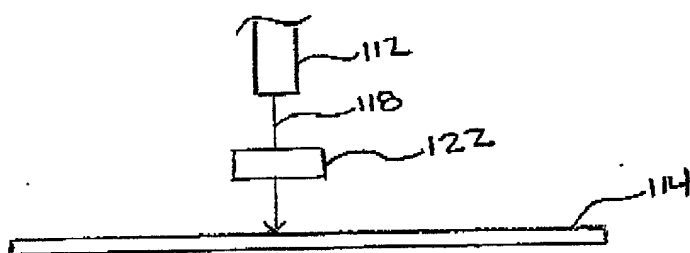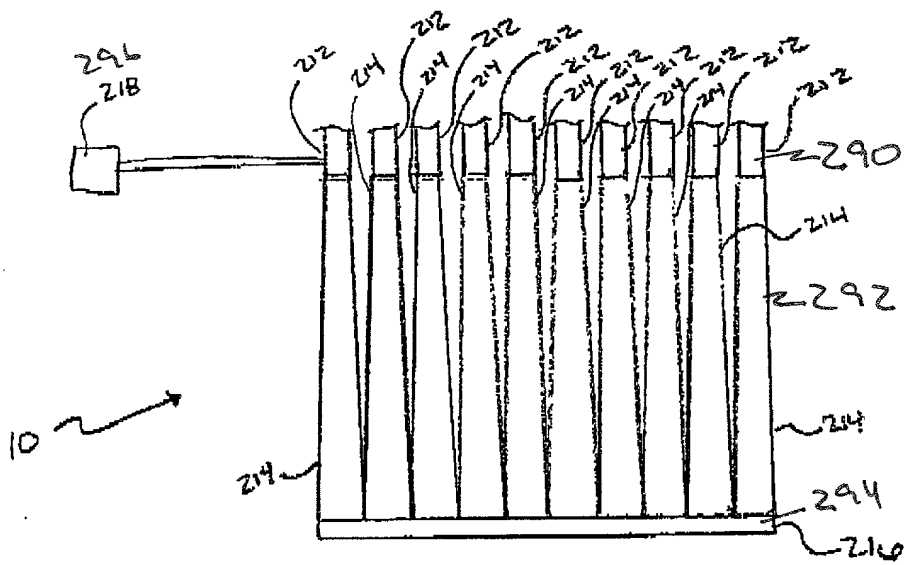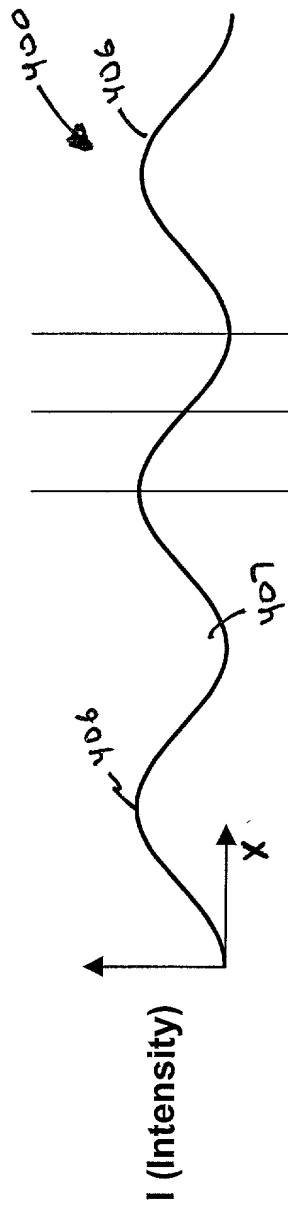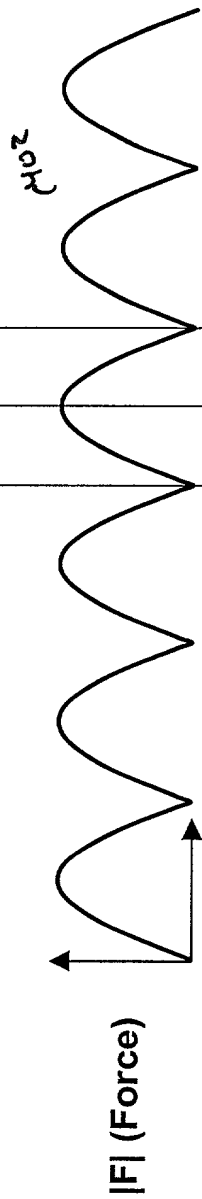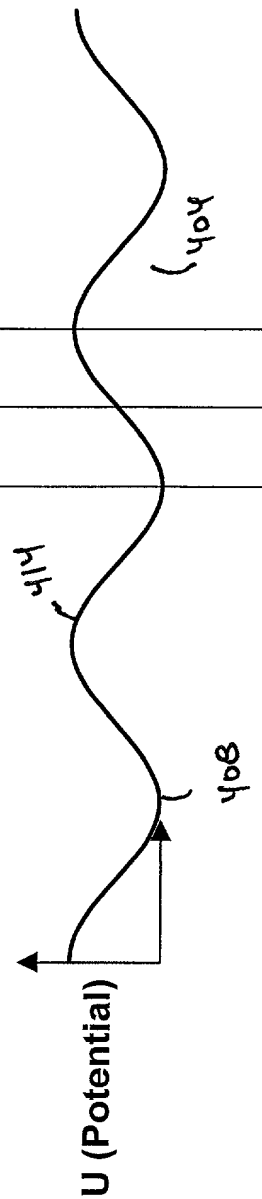
Fig. 8

Fig. 9A

Fig. 9B

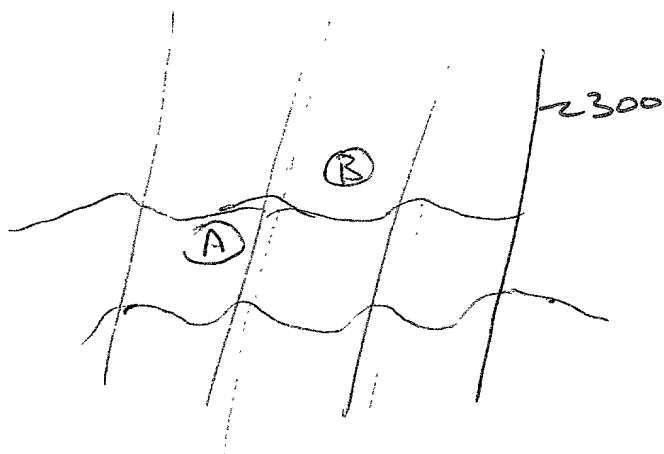Fig. 10

Fig. 11A

Fig. 11B

Fig. 11C

I (Intensity)

|F| (Force)

U (Potential)

X

Fig. 12A

Fig. 12B

Fig. 12C

U (potential)

X

310

312   316

314

306

316

Fig. 13A

U (potential)

314 310

312

318

316

Fig. 13B

314

312

316

316

308

318

Fig. 13C

Particle
Flow
↓ ~320

Identify and
Separate

322 ~326

~324

General Particle
Sorting from
1-D Source

A

Fluid
Flow
↓ ~330

Optically
Identify and
Separate

332 ~336

~334

Optical Cell
Sorting from
1-D Source
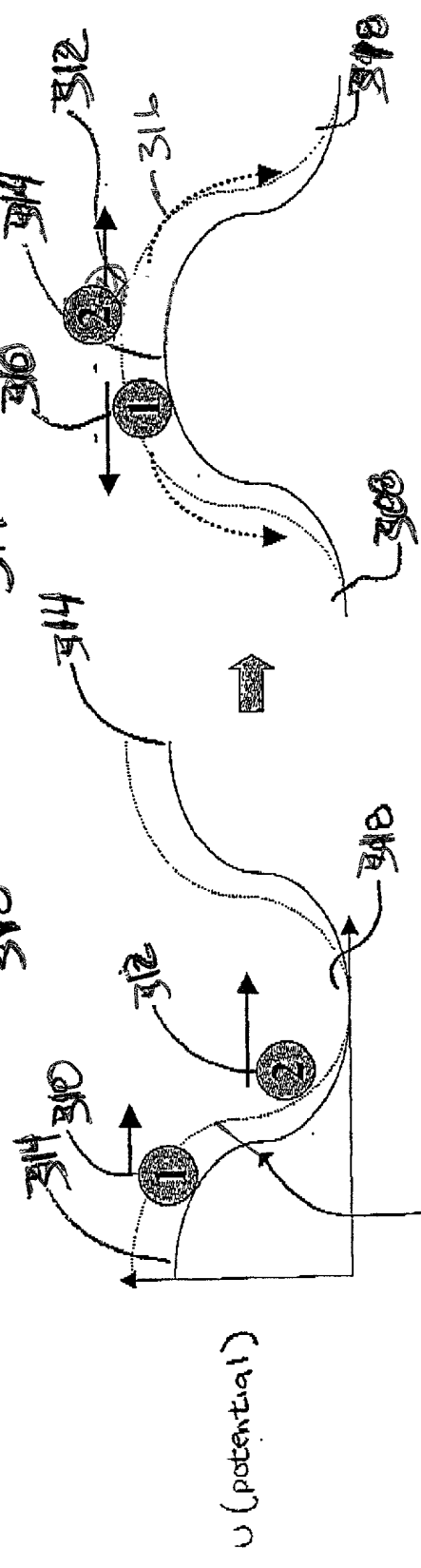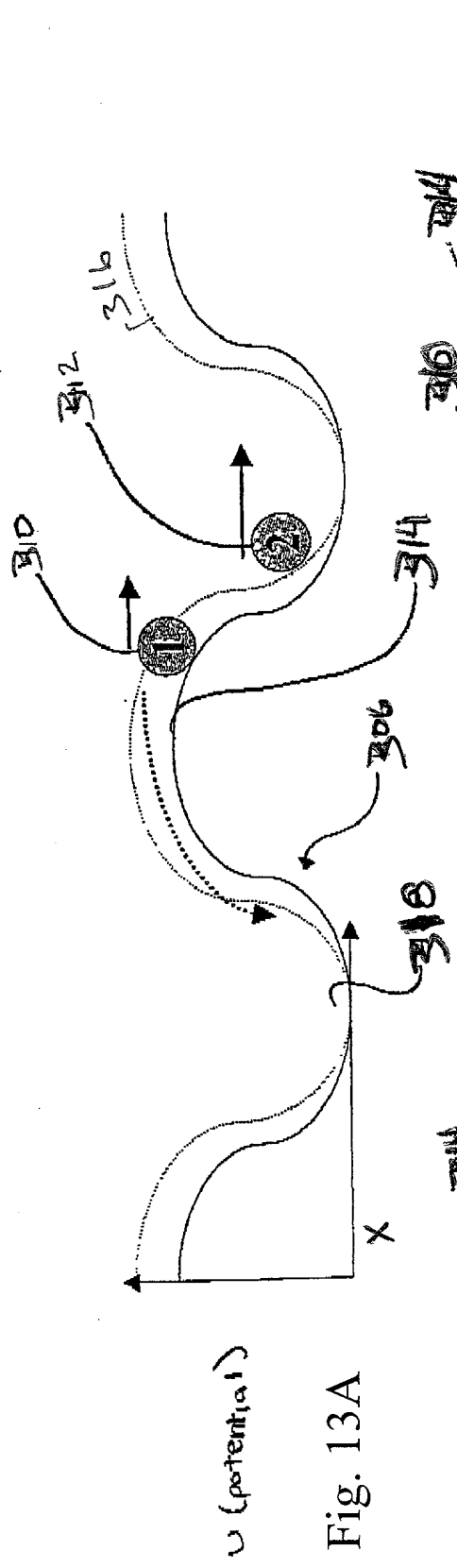
B
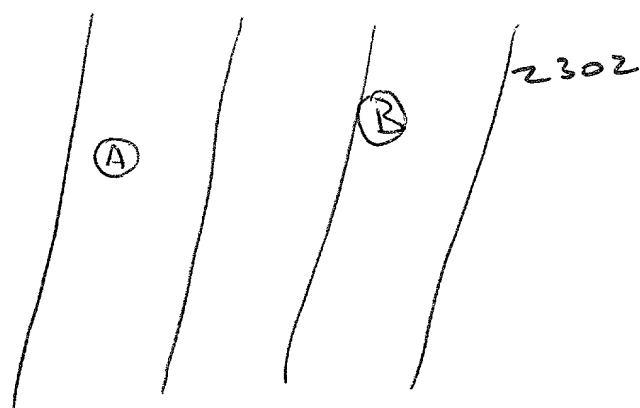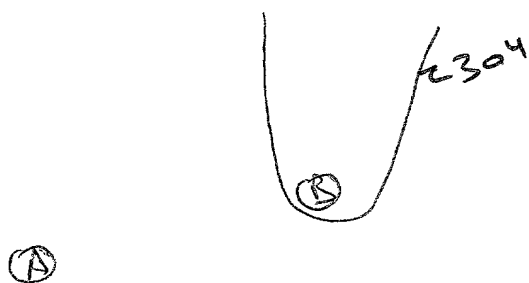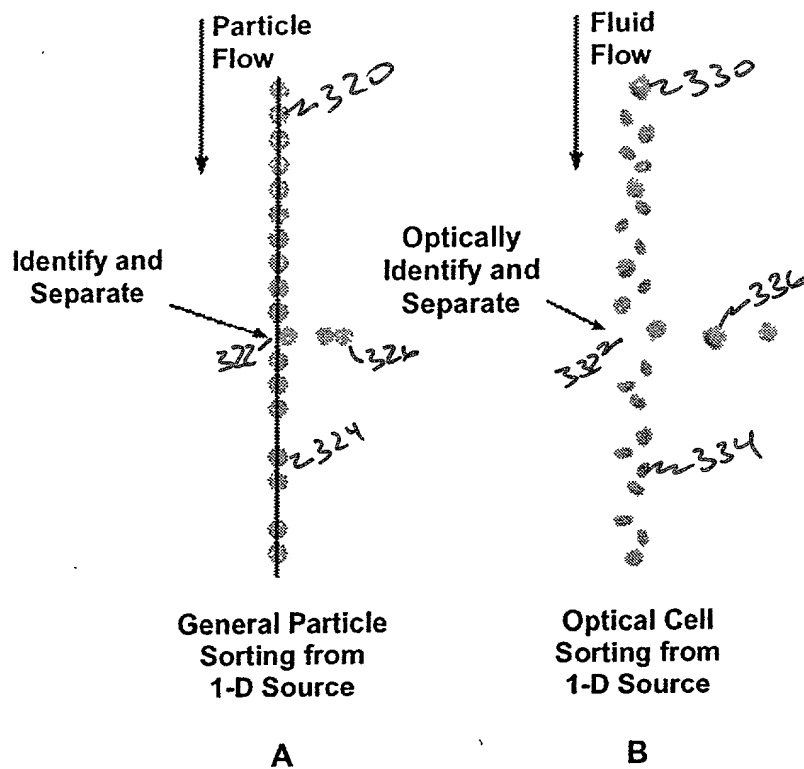
Fig. 14A   Fig. 14B
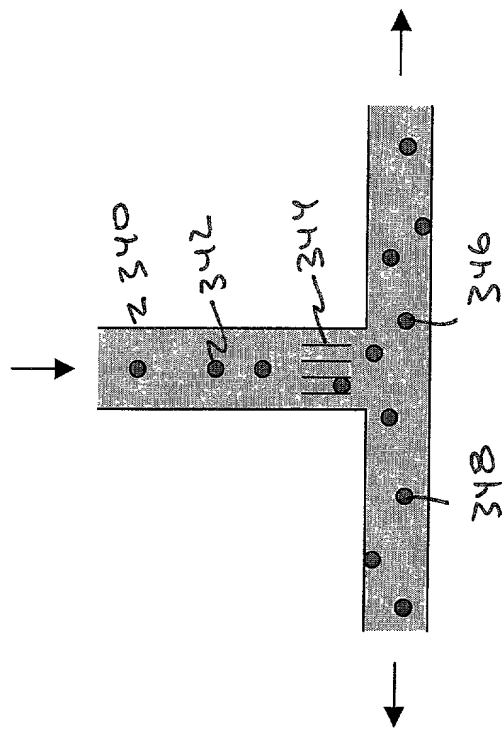
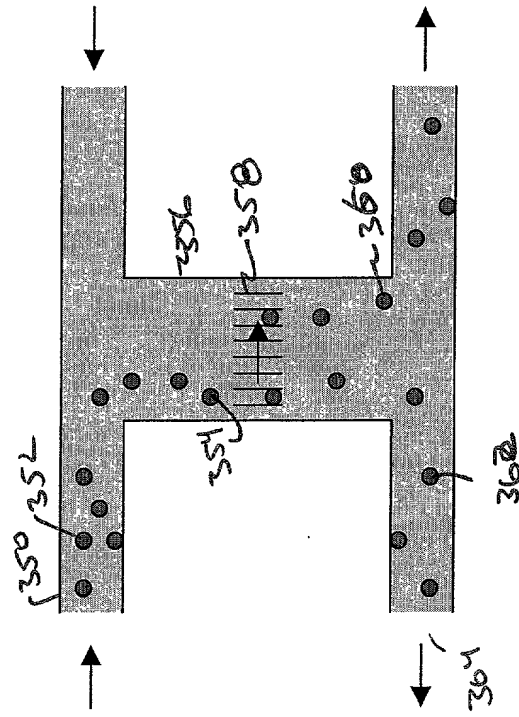# Sorting in a T-channel
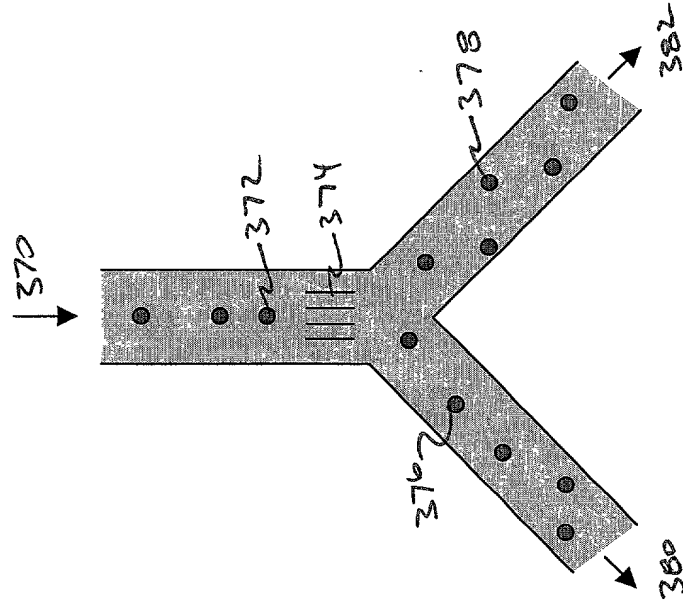

Fig. 15

Sorting in an H-channel

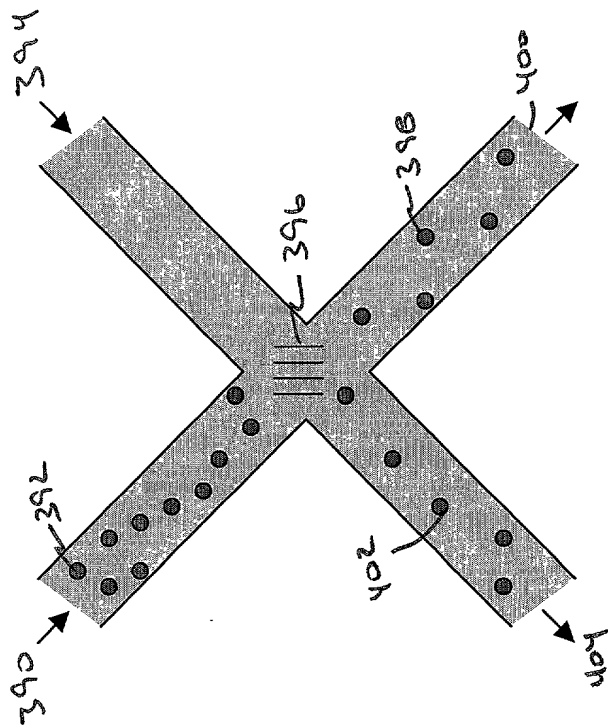Fig. 16

Y-Channel

Fig. 17

X-Channel
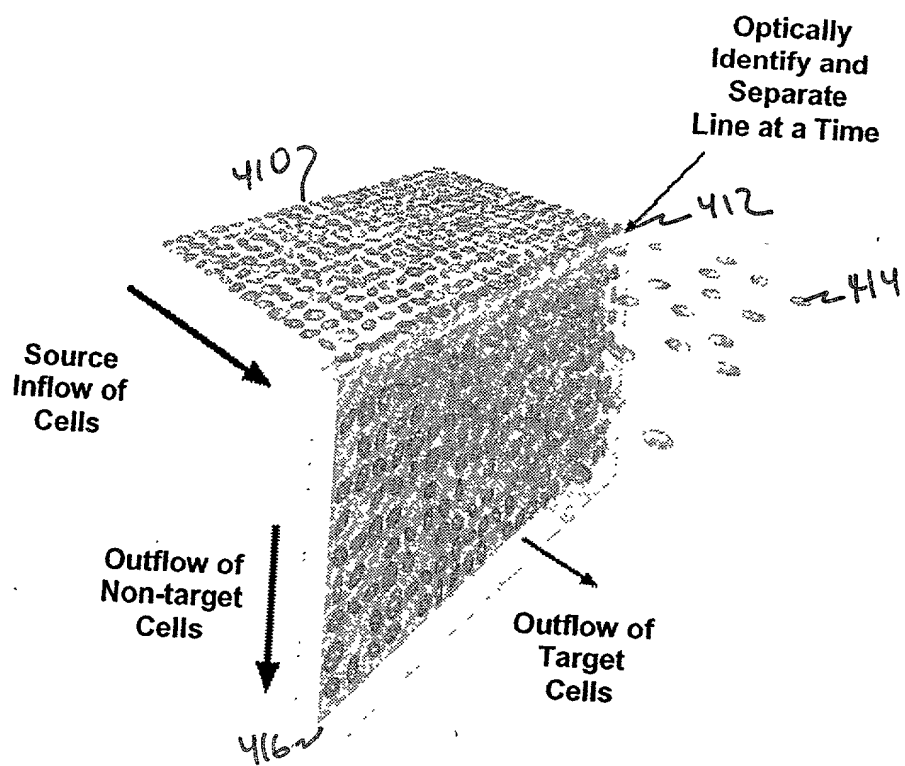

Fig. 18

410

Optically
Identify and
Separate
Line at a Time

412

414

Source
Inflow of
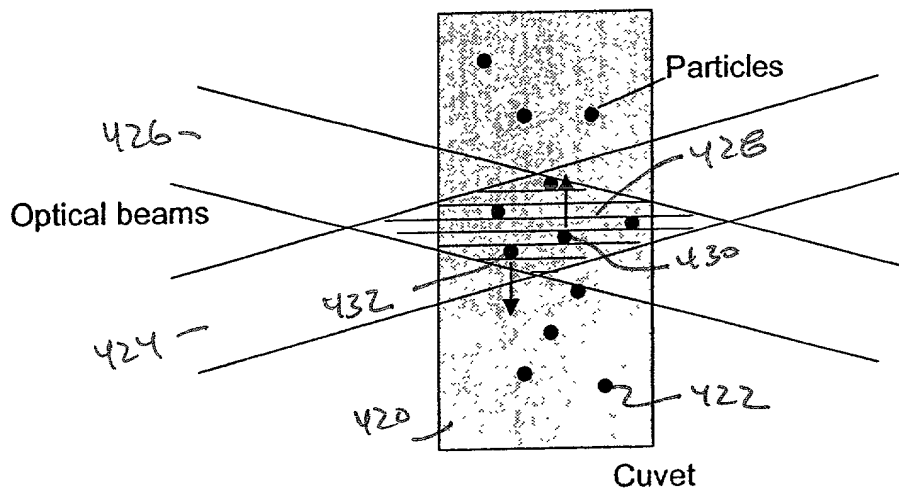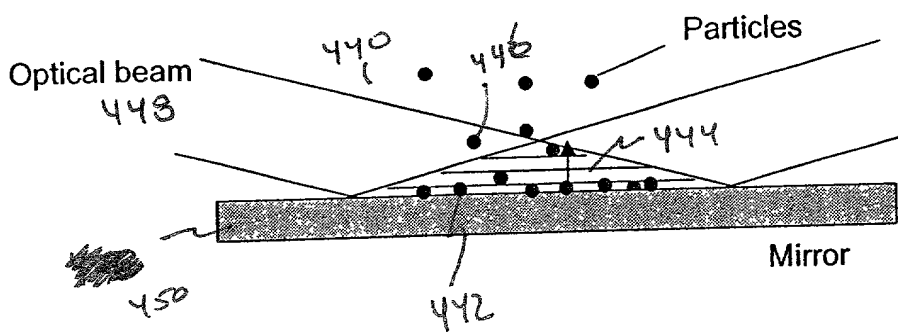Cells

Outflow of
Non-target
Cells

Outflow of
Target
Cells

416

Fig. 19

Fig. 20

Fig. 21

Fig. 22

Fig. 23

Input

Recycle
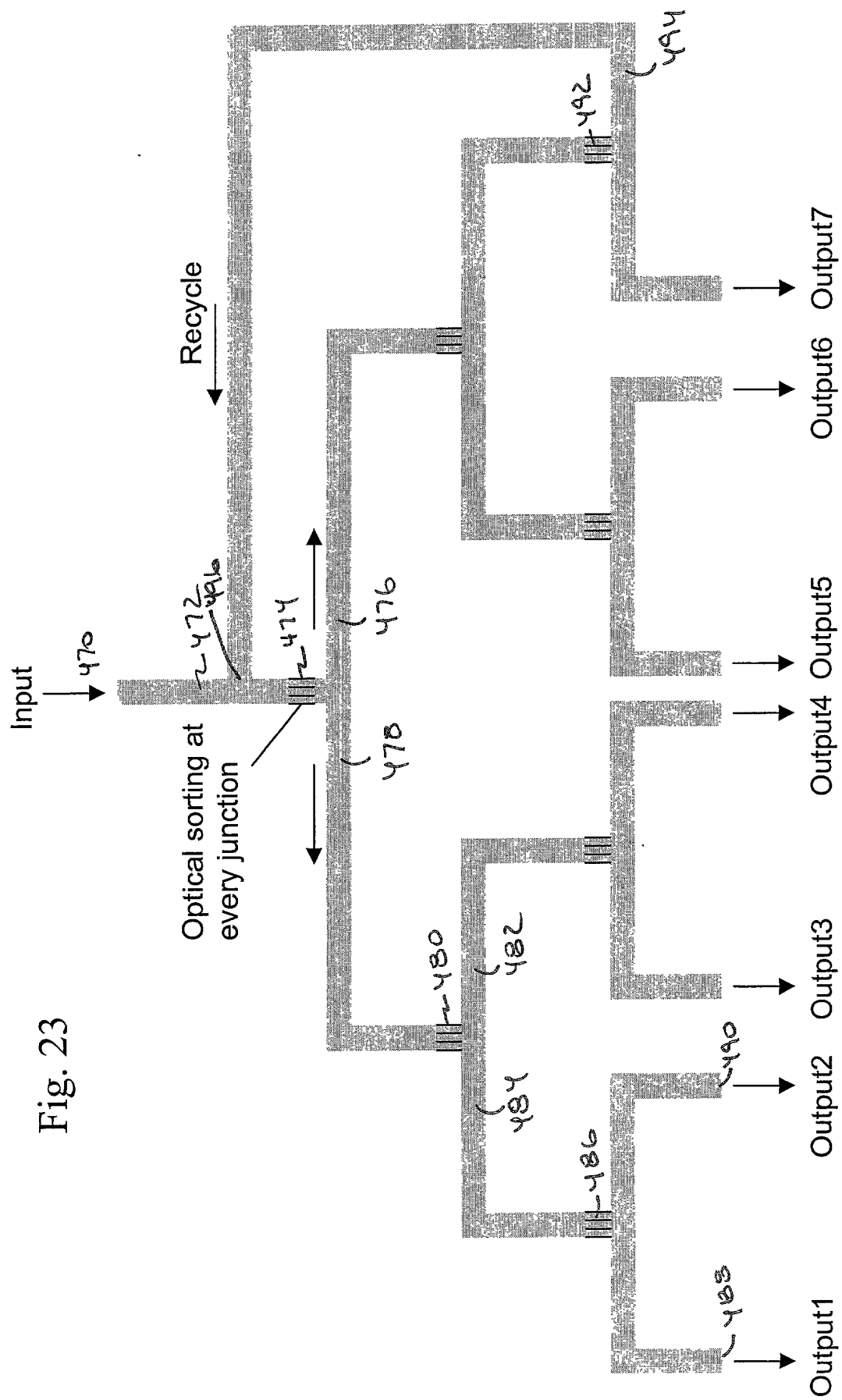
Optical sorting at every junction

470

472

474

476

478

480

482

484

486

488

490

492

494

Output1
Output2
Output3
Output4
Output5
Output6
Output7

502

504

500

Fig. 24

512

514

510
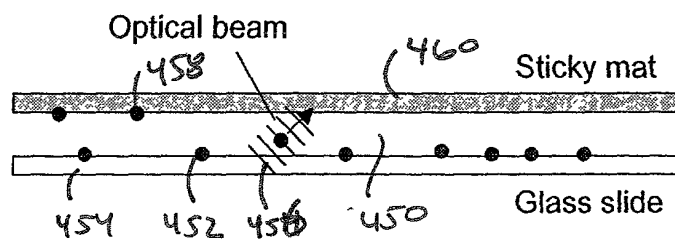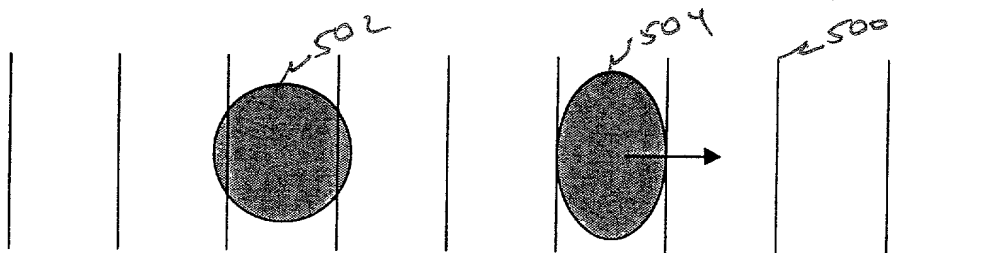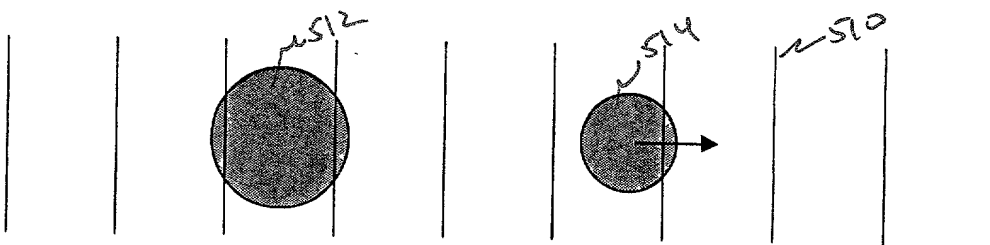
Fig. 25

Scatter Force Separation

Fig. 26

Before:

Collimated optical
beam

Mixed particles

Capillary

Laser 520

Lens 522

528 526

524

After:

Laser 520

522

524

526'

528'

Particles separated based on speed

Input 2 532

Switching beam 540

Input 1 530

534

Output 1 536

Fluidic channels

538 Output 2
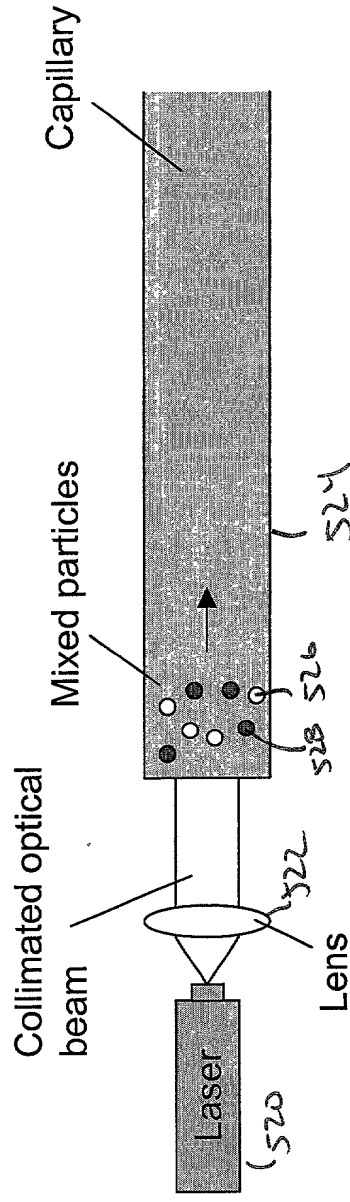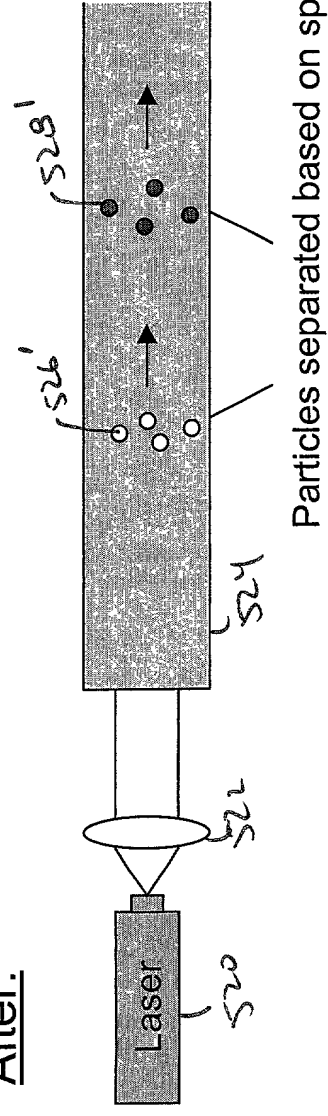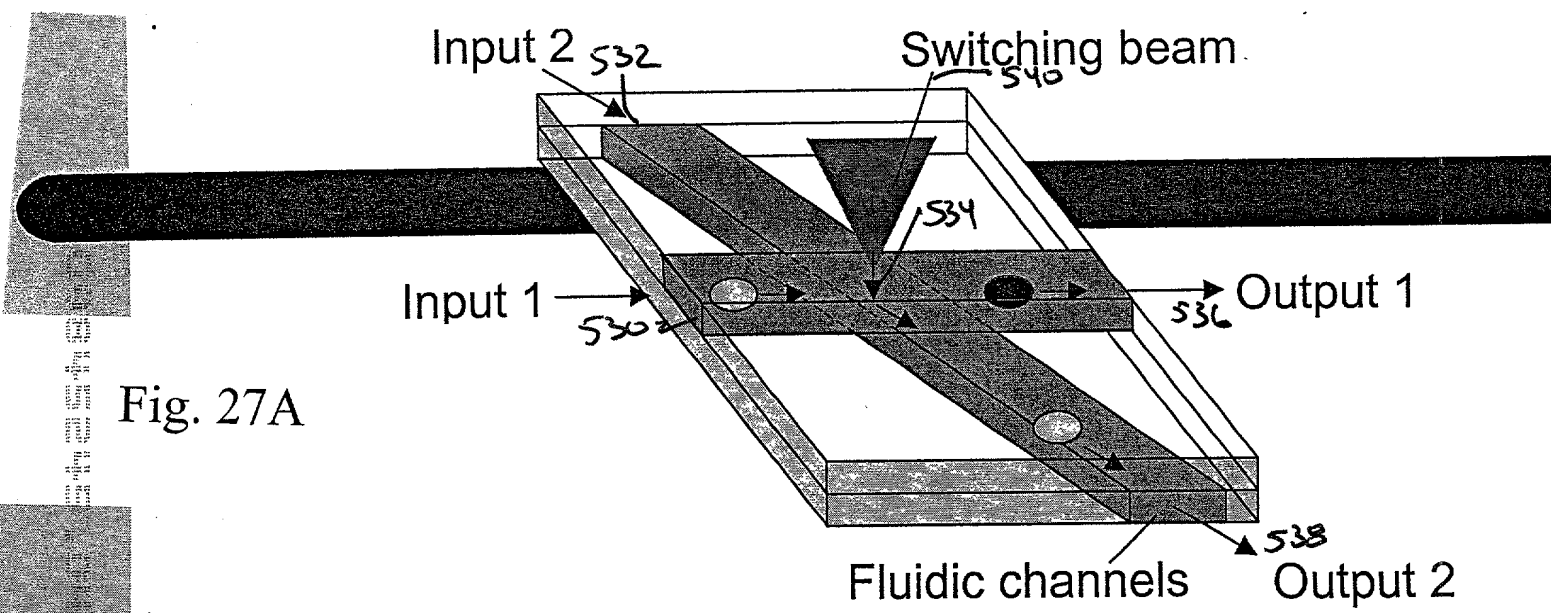
Fig. 27A

View from the side:

Optical beam **off**:

530

532

536

538

Fig. 27B

Optical beam **on**:

540

530

532

536

538

Fig. 27C

Fig. 28

$$n_1 > n_m > n_2$$

Fig. 29

Optical tweezer array

Cells or other
biological sample

572

578

576

574

570

Patterned substrate
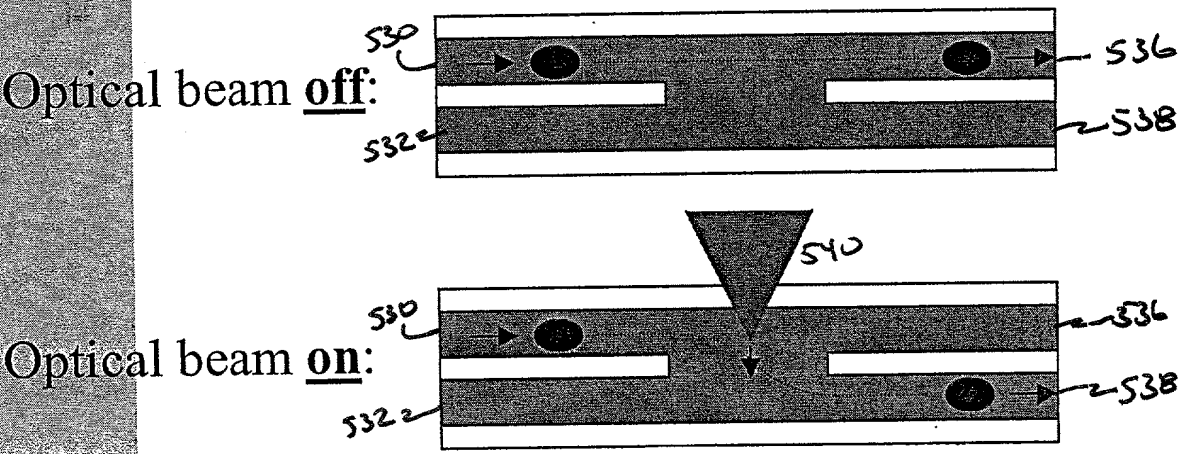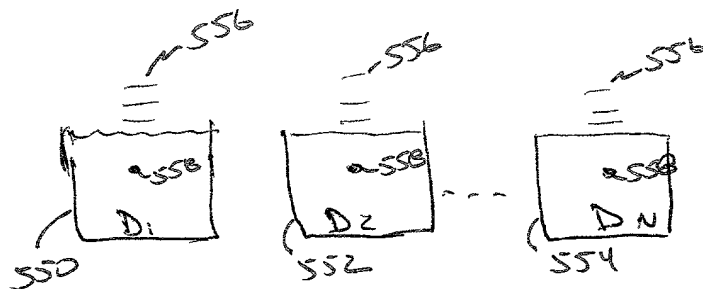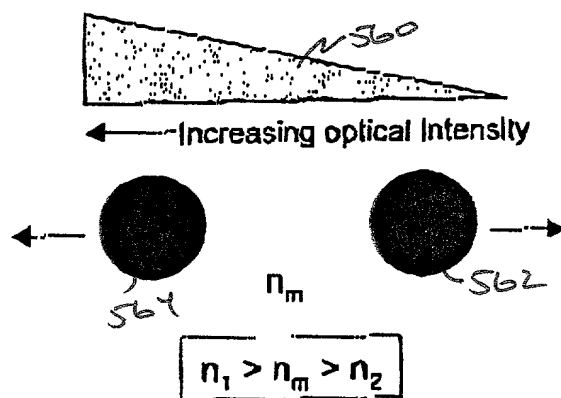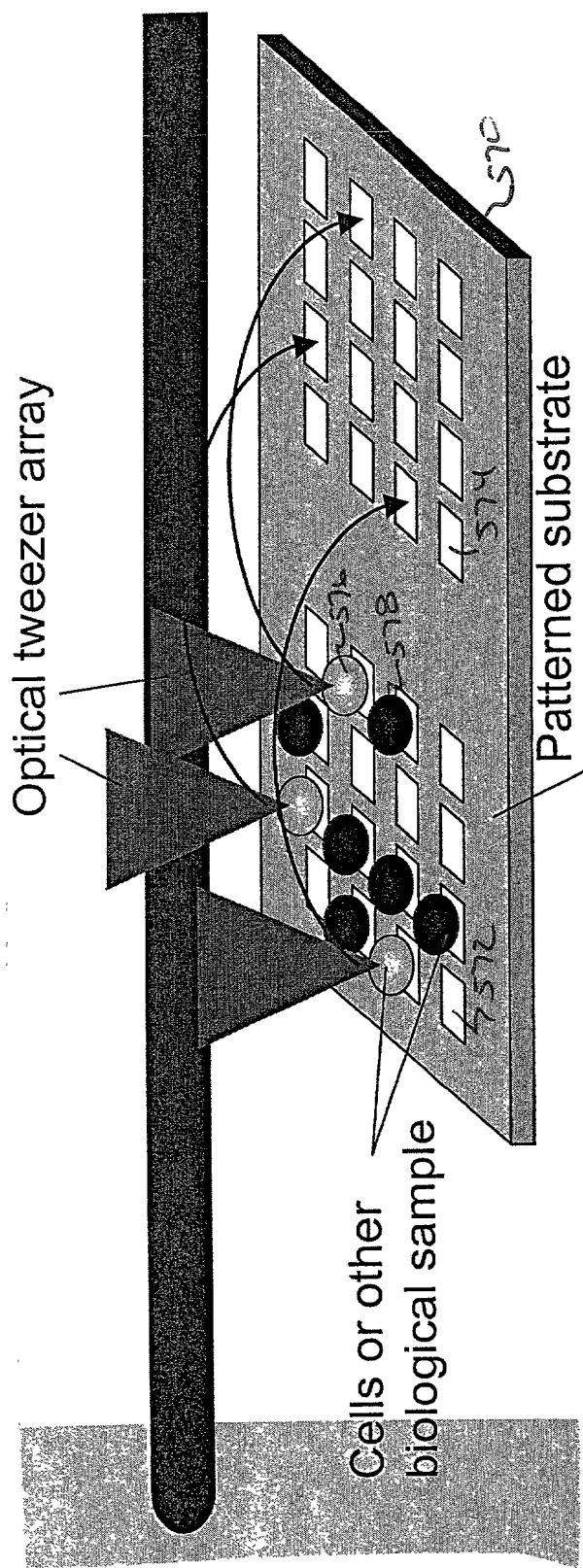
Fig. 30

Hemoglobin-O$_2$ Absorption Spectrum
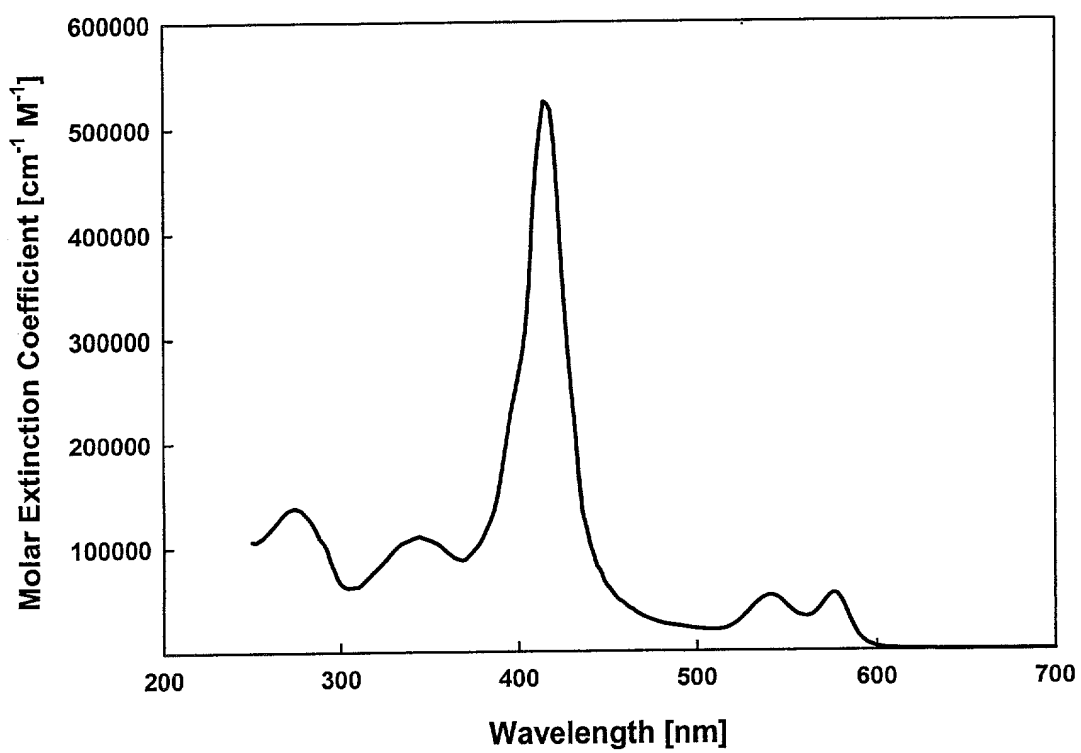
Fig. 31
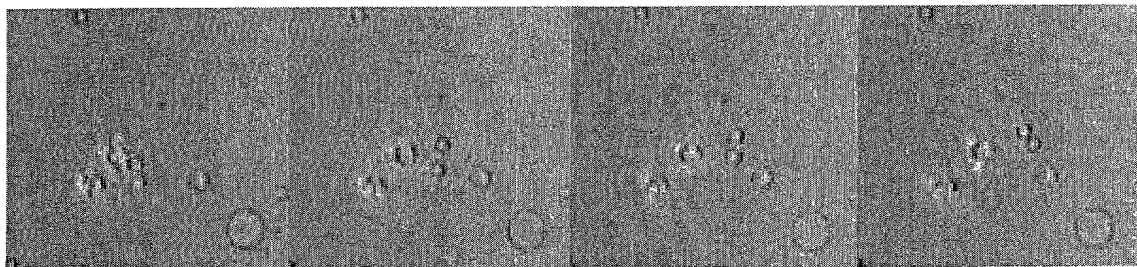
Fig. 32
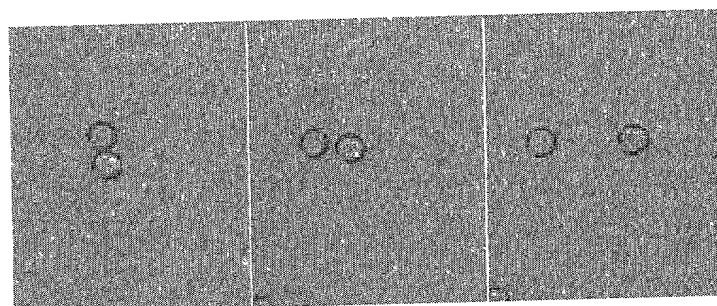
Fig. 33
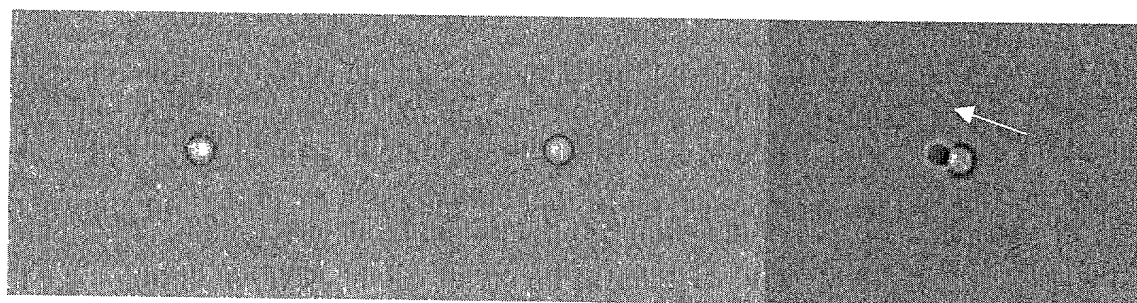
| Before | After | Difference |

Fig. 34

DISTRIBUTION OF ESCAPE VELOCITIES
Reading Taken in PBS/1% BSA Buffer
Rain-X Coated Slide/Cytop Coated Coverslip

— RBC, Individual 1
— RBC, Individual 2
— WBC, Individual 2

% of Cells Tested

Escape Velocity (um/sec.)

Fig. 35

Fig. 36